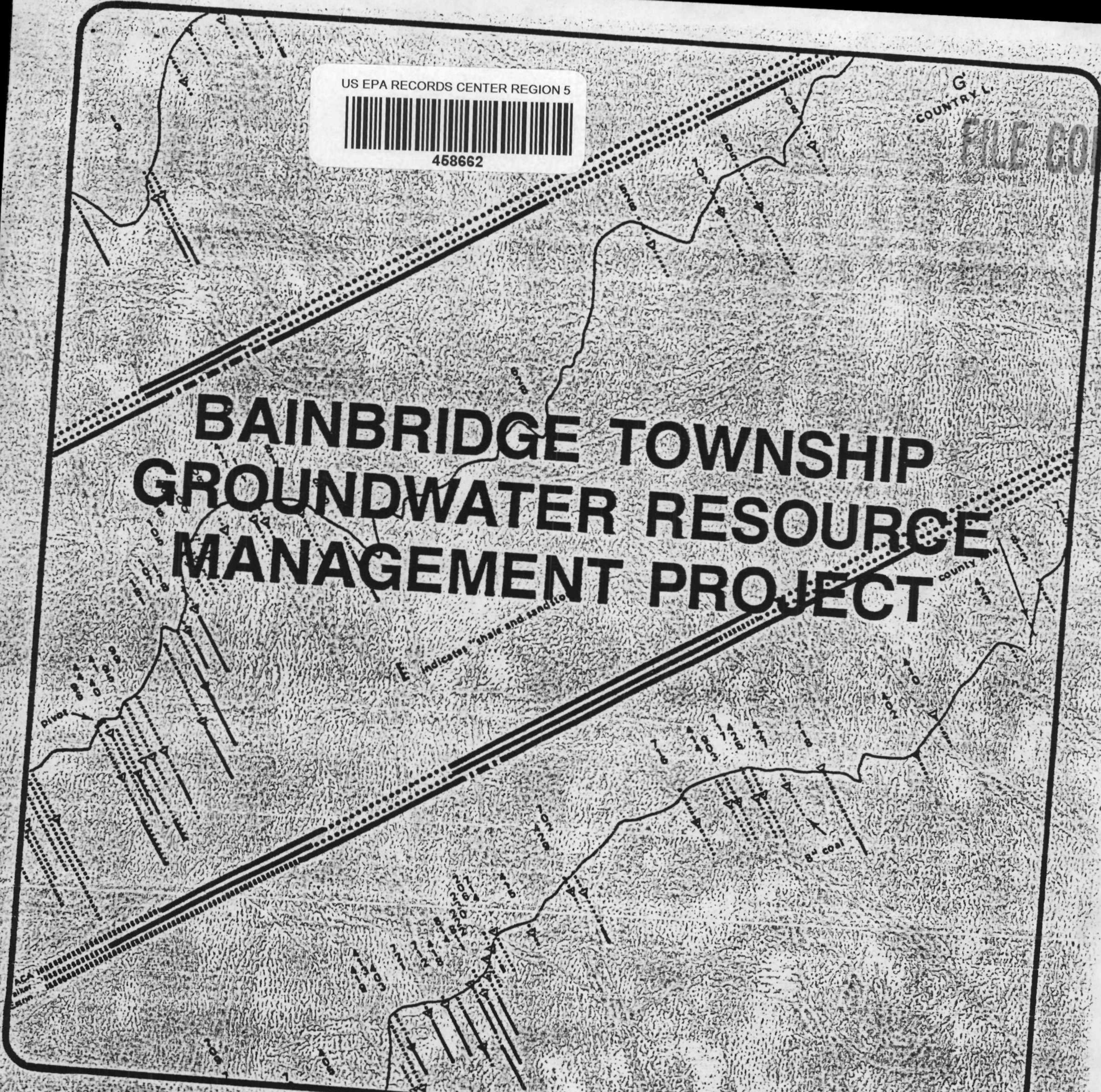


BAINBRIDGE TOWNSHIP GROUNDWATER RESOURCE MANAGEMENT PROJECT

NORTHEAST OHIO AREAWIDE COORDINATING AGENCY

NOACA

BAINBRIDGE TOWNSHIP, GEAUGA COUNTY, OHIO

GROUNDWATER RESOURCES MANAGEMENT PROJECT

NORTHEAST OHIO AREAWIDE COORDINATING AGENCY

OCTOBER, 1985

1.0 INTRODUCTION

This report provides an overview of the groundwater resources of Bainbridge Township, Geauga County, Ohio and orients this information to implementing a community level groundwater resource management program. There are three primary elements to this report. The first element describes the location and extent of groundwater resources within the township, and summarizes the information base currently available. This section discusses the availability of water within the township, provides a groundwater contour map indicating flow directions, and summarizes well depth and developed capacity information.

The second element reviews a series of management tools developed by NOACA for Bainbridge Township. Included is a discussion of the use and limitations of well log data, groundwater level data and the groundwater contour maps derived from them. Also provided is an overview of water quality data as it applies to specific pollutant source types.

The final element outlines several groundwater management action steps which can be undertaken by the township to provide useful, organized data and data analyses, to facilitate the ongoing local groundwater decision process.

Since this report is intended to provide a framework for community level groundwater management based upon the initial interpretation of existing groundwater conditions, an attempt is made throughout to translate groundwater principles to terms that are understandable to the public. The report does not provide definitive answers to questions about site specific conditions. The reader is cautioned, therefore, not to make simplified generalizations which can be misleading when applied to a specific site. The information herein is provided as a starting point for answering these questions.

2.0 GROUNDWATER BASELINE

2.1 Groundwater Information Sources

A considerable volume of information exists that pertains to the groundwater resources of Bainbridge Township. While this information varies in quality and applicability, the total body of information of potential interest is formidable. The value of groundwater as a developable resource begins with the subsurface geology of the area. A major contribution to knowledge regarding the geologic formations underlying the township is the landmark work accomplished by Pedry (1951). Pedry's geologic map of the township has been largely supported by wells drilled since its creation, and his description of the individual formations is the best available. The unpublished work of Baker (1964) further refined Pedry's findings particularly regarding the character and extent of glacial deposits. Baker also placed the geologic materials in the context of their groundwater potential. Estrin (1978) reviewed available information and developed a groundwater aquifer map and a potential recharge rate map. Walker (1978) has provided a detailed groundwater availability map which, as will be discussed shortly, is considered to be the most valid description of the location and extent of the major aquifer systems within the township.

Banks and Feldmann (1970) compiled a series of definitive papers on the regional geology of northeast Ohio. While this work is the most comprehensive review of the intricacies of the individual geologic units of the area, its regional scope has limited specific applicability to Bainbridge Township.

Ohio Department of Natural Resources, Division of Water, maintained water well level records at the Chagrin Falls wellfield from 1949 through 1978, when the responsibility was turned over to USGS. Level measurements from wells in surrounding areas are also included in this program.

Water One, a Chagrin falls based water conditioning system supplier, has made numerous analyses of groundwater quality from the wells of its clients within the township. This company has expressed a willingness to make this information available to the township.

USGS (1978) analyzed groundwater levels and water quality at several locations within the township. Included in this document is a coarse groundwater contour map. USGS (1980) also collected, but did not fully analyze, a considerable body of information on the levels and quality of water in the township. This information is being included in the program that USGS is currently undertaking throughout Geauga County. Current work by USGS scheduled for completion in 1987, will address groundwater management issues on the county scale.

The largest single source of information regarding groundwater in the township is the Well Logs and Driller's Reports File maintained by ODNR's Division of Water since approximately 1950. Records of an estimated 2,000 wells within the township are currently included in this file representing information of varying completeness and accuracy. Well logs can provide information on well depths, geological materials encountered in the drilling operation, and capacities of wells to produce water. Reliable well log records, in sufficient numbers, coupled with detailed knowledge of geologic formations underlying the township, can provide the necessary framework for defining the location and extent of aquifers, and the direction of groundwater movement. In cases where the reliability of well log records is uneven, a larger number of well records must be consulted. In the present study, approximately 800 records were consulted. Section 3.1 of this report will discuss well log data in detail. Plate 1 portrays the wells which have been located in Bainbridge Township. The well numbers in Plate 1 correspond to the well numbers used in Appendix A. This appendix summarizes data contained in all logs reviewed for this project.

Taken in total, this body of information provides a solid foundation upon which to build a groundwater management program. Given the volume and character of the groundwater resource information base in Bainbridge Township, it is necessary to develop a process by which that information can be organized and used to assist in site-specific evaluations. This process is described in the elements which follow.

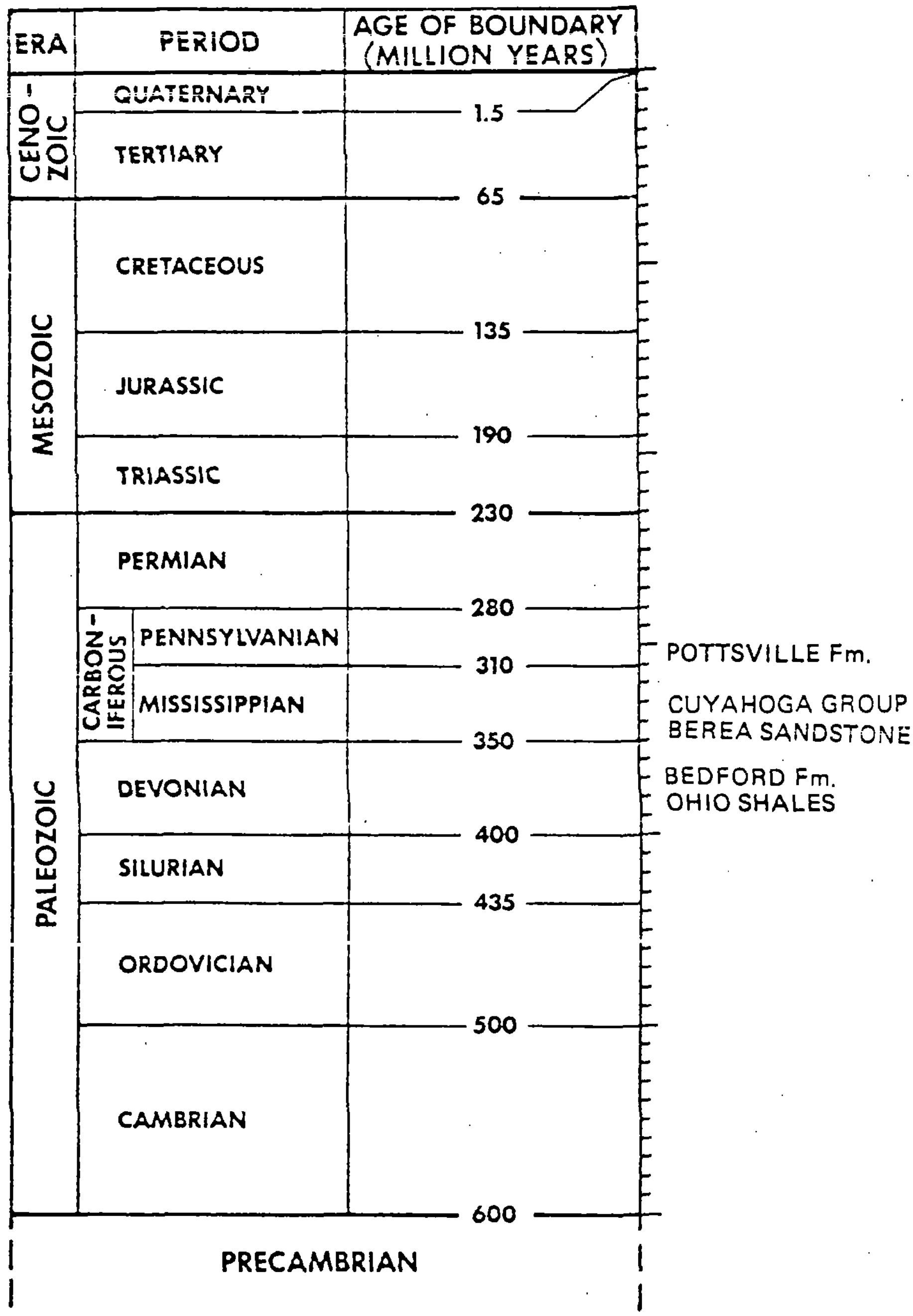
2.2 Summary of Existing Conditions

Groundwater within the township is plentiful, widely available and of generally good quality. It is capable of being produced at rates sufficient for small domestic supplies virtually everywhere in the township, and at much larger rates in certain limited areas. Indications are that fresh water in Bainbridge is typically found above an elevation of 800 feet above mean sea level. This means that fresh water depths range from at least 50 feet in the lowest lying portions of the township to more than 400 feet in the highest areas.

Geology

In excess of 2,000 wells have been developed within the township since 1950. These wells produce water from four distinct geologic units which are considered to be hydraulically connected (water is free to pass from one unit into another). Three of these units are bedrock units and include the Pottsville Formation of Pennsylvanian age, and the Cuyahoga and Berea Formations of Mississippian age (see Figure 1 for a general geologic column of the township). Virtually no wells are developed in the rocks of Devonian age which underlie the Berea Formation. The fourth aquifer unit consists of unconsolidated deposits of varying amounts of clay, silt, sand and gravel which were largely deposited in association with the glacial activity of Pleistocene age.

FIGURE 1: GENERALIZED GEOLOGIC COLUMN



After Banks and Feldmann (1970)

The Pottsville Formation is the most developed aquifer, and consists of the Connoquenessing Sandstone, the Sharon Shale, Sharon Sandstone and Sharon Conglomerate Members. This formation occurs virtually anywhere that the surface elevation exceeds 1,100 feet, but can be found at depths ranging as low as 900 feet on occasion. The Cuyahoga Formation consist predominantly of shale, with irregular interbeds of siltstone and occasional sandstone lenses. The top of the formation can be high as 1,100 feet. However, pre-Pottsville erosion has removed the upper part of this formation throughout much of the township. This occurrence accounts for the presence of Pottsville rocks in some locations at elevations less than 1,100 feet. The Berea Sandstone is found at elevations varying from 900 to 830 feet within the township and forms the deepest aquifer in the township. Wells developed in unconsolidated materials are generally located in areas of pre-glacial valleys which were subsequently filled following the retreat of the glacial ice.

Aquifer Distribution

The distribution of the individual aquifer units within the township is subject to some dispute. Two contradictory maps have been prepared - one by Walker (1978) and the other by Estrin (1978). Unless rectified, these maps can lead to widely varying groundwater interpretation in certain areas. Towards this end, Plates 2-5 were prepared with the use of well log data and knowledge of the subsurface geology of the township. Plate 2 indicates the locations of the geologic cross-sections contained in Plates 3 and 4. Plate 5 shows the areal distribution of the developed aquifer, where such a determination could be made from the well log and cross-section data.

The cross-sections in Plates 3 and 4 indicate the formational contacts among the Pottsville, Cuyahoga, and Berea Formations. Under each well log plot, the primary aquifer is identified. Agreement or disagreement of the Walker and Estrin maps is also indicated.

Analysis of this information shows that Walker is in agreement with the well log data 79 percent of the time while Estrin is in agreement only 52 percent of the time. Comparison of the aquifer identifications in Plate 5 to the Walker map, further strengthens the conclusion that the Walker map is much more representative of aquifer extents in the township.

Of the well logs investigated in the present study, 56 percent were served by the Pottsville Formation, 21 percent by the Cuyahoga Formation, 12 percent by unconsolidated deposits, and 11 percent by the Berea Formation.

Water is available at comparatively shallow depths within the township as shown in Table 1. The wells developed into the Berea Formation tend to be the deepest with most wells exceeding 100 feet in depth, and 30 percent exceeding 150 feet. The Pottsville Formation wells tend to be the shallowest, with no wells exceeding 150 feet in depth. Plate 6 shows the areal distribution of well depths in the township.

Table 1: Distribution of Aquifer Well Depths

Aquifer	Percent of Wells by Depth Range (in feet) 0-50	50-100	100-150	150-200	>200	Number of Wells
Berea Formation	0	12	47	14	16	49
Pottsville Formation	15	68	17	0	0	222
Cuyahoga Formation	16	46	29	5	4	104
Valley Deposits	21	42	25	1	2	62
All Wells	14	53	24	5	3	437

Groundwater Quantity and Quality

Well log pump tests may be less than ideal as a means of quantifying groundwater yields. The specific limitations of these tests will be discussed in more detail in Section 3.1, but they generally include, (1) the lack of standardized procedures, (2) the driller's principal interest in determining the suitability of the well for its intended purpose and not in determining maximum yield, and (3) the lack of the means to determine any adverse effects on nearby wells. In spite of these limitations, a distributional analysis of well log pump tests can be informative.

Table 2 portrays the results of such an analysis for 382 wells where sufficiently complete information was available regarding the pump test, and where the aquifer type could be determined. Plate 7 indicates the map locational distribution of these values.

Table 2: Percentage Distribution of Aquifer Yields

	Percent of Wells Producing Greater Than			
Aquifer	5 GPM	10 GPM	20 GPM	Number of Wells
Berea Formation	100	62	7	42
Pottsville Formation	95	56	9	204
Cuyahoga Formation	79	48	4	47
Valley Deposits	87	49	22	89
All Wells	91	54	9	382

This analysis indicates that 91 percent of the developed wells in the township can easily produce enough water for an individual household. The areas most at risk in terms of not being able to develop a sufficient water supply, are those which must tap rocks of the Cuyahoga Formation or the valley fill deposits. The Berea and Pottsville Formations are very reliable sources of domestic water supply. Whereas a large percentage of valley fill deposits may produce minimal water supplies, 22 percent of wells located in these deposits are capable of producing very large supplies.

Examination of the volume of water produced per one foot of aquifer drawdown provides additional insight into aquifer behavior. Table 3 contains a summary of the distribution of the values calculated by dividing the total gallons of water pumped by the drawdown recorded during the well log pump tests.

Table 3: Percentage Distribution of Groundwater Yield per Foot of Drawdown

	Percent of Wells Producing More Than			
Aquifer	500 gal/ft	100 gal/ft	40 gal/ft	20 gal/ft
Berea Formation	17	27	34	71
Pottsville Formation	15	42	74	89
Cuyahoga Formation	8	24	39	63
Valley Deposits	19	49	77	84
All Wells	14	37	61	80

A large percentage of the wells developed in the Pottsville Formation and in the valley deposits yield large amounts of water with minimal drawdown. The Berea and Cuyahoga Formations generally result in much larger drawdowns in order to supply an equivalent amount of water. This increases the chances that a given well in these formations can adversely affect surrounding wells.

The best estimate of the average annual groundwater recharge rate that exists is that reported by USGS (1978). This rate is three to seven inches per year or 200 to 500 gallons per acre per day. This recharge rate compares to an estimated residential demand of approximately 250 gallons per household unit.

Readily available data on the quality of the groundwater within the township is scarce. The background quality of the township's aquifers indicates the water to be of a calcium-magnesium-bicarbonate type with some local differences showing a sodium-potassium-bicarbonate water. Iron and manganese concentrations are often elevated, but generally within drinking quality standards. The water is rated as very hard (total hardness greater than 150 mg/l).

3.0 GROUNDWATER DATA ORGANIZATION AND USE

3.1 Evaluation of "Well Log and Drilling Reports"

"Well Log and Drilling Reports", commonly referred to as simply well logs, are prepared by well drillers when completing a well. The logs are filed with ODNR Division of Water, and since 1978 with the Geauga County Health Department. Within limits, these well logs provide the most comprehensive and most useful information available regarding local subsurface geology and aquifer attributes. The typical well driller is expert in drilling and finishing wells for water supply. He often relies on personal experience as a guide for locating wells and determining the appropriate depth to drill. Some problems with the use of well logs for interpretive purposes are encountered due to the fact that many well drillers lack formal geologic education. Problems include the lack of a consistent terminology to describe and identify geologic units, and the incompleteness or questionable accuracy of observations made relative to pump tests and water level measurements. Whereas considerable caution must be employed in interpretations based on a small number of logs, large numbers taken as a body can be quite useful.

The single largest limitation affecting the usefulness of well logs is the lack of information specifying locations of the wells. Of the more than 800 logs reviewed for this project, not more than 500 could be located to the individual property level. None could be precisely located. Even with this limitation, locating 500 wells to the individual property level is a very useful body of information.

A second limitation in the use of well logs is the lack of consistent terminology and the occasional misidentification of geologic units. A geologist with knowledge of the local stratigraphy can usually interpret the logs and reliably identify the formations being described. Even then, a large number of logs may be needed to discern a pattern. As long as a generalized geologic column is used for reference with the well log descriptions, few cases occur where the units described cannot be identified. The geologic units used in the evaluation of Bainbridge Township are limited to the following: unconsolidated deposits, the Pottsville Formation, the Cuyahoga Formation, the Berea Formation, and Devonian shales. Within this framework of units, the following cautionary notes are in order.

1. Some drillers will identify stratigraphically higher elevated members of the Pottsville Formation as being the Sharon Sandstone. Most specific references to the Sharon should be considered as being some member of the Pottsville.

2. The Sharon Shale is a variable thickness unit of irregular extent. It lies between the Sharon and Connoquenessing Sandstones of the Pottsville Formation. When found, this shale is usually encountered at elevations of 1150-1200 feet. A driller will occasionally consider this shale to be the Cuyahoga Formation and will mistakenly label the underlying Sharon Sandstone as the Berea Sandstone. Within the Cuyahoga Formation, a sandstone lens will be occasionally encountered which attains 20 feet in thickness. This lens, which is usually the Aurora Sandstone, may also be mistaken for the Berea. Elevation is the key to identifying the Berea Formation. Any sandstone encountered below an elevation of 900 feet in the township can safely be considered to be the Berea. Sandstones above 900 feet will not be the Berea, but will be of the Pottsville or Cuyahoga Formations.

3. Once bedrock is actually encountered, only bedrock will be found below it. Descriptions of sand and gravel or clay lenses below rock units indicate one of two things: either a soft sandstone or shale has been encountered and the rock has disintegrated prior to reaching the surface, or the driller encountered

boulders mixed in the unconsolidated materials, and has mistaken these rocks as bedrock. Nearby well logs can usually differentiate these occurrences.

4. Siltstone, a rock unit of a grain size intermediate between sandstone and shale, is a term which is not commonly used in the well logs reviewed. The Cuyahoga Formation consists predominantly of shale with thin, irregular siltstone interbeds. The term "sandy shale" usually refers to these beds. A driller may occasionally refer to them as "slate". Slate is a metamorphic rock which is not found anywhere in the township at the depths under consideration.

5. The Sunbury Shale is usually found lying immediately above the Berea Sandstone. This shale ranges from 6-8 feet in thickness and is a characteristic black in color. This contrasts with the blue-gray shales of higher numbers of the Cuyahoga Group. Where black shale is noted on well logs, the underlying sandstone can confidently be identified as being the Berea.

6. The term "pebble rock" almost always refers to the Sharon conglomerate. (A conglomerate is a sandstone unit which contains a large amount of pebbles.) There are local cases where lower units may contain pebbles, and can be misidentified as the Sharon. In this case, surrounding well logs are the key to proper identification of "pebble rock" units. The reference to gravel layers below sandstone bedrock usually refers to the encountering of a conglomerate lens.

7. "Hardpan" is a term used to describe dense clay till layers usually containing pebbles. "Gumbo" refers to an unconsolidated material deposit which has a mixture of grain-sizes. Usually it describes the stony till layers that other drillers call hardpan.

Pump Tests

Well drillers generally, but not always, perform a pump test to determine adequacy of a new well. This test involves pumping water from a well at a constant rate for a specified time period, and measuring the drop in water level before and after pumping. The driller attempts to determine the proper size of the pump to be installed in the well with the use of this test. The objective is to pump at a rate which will not cause a temporary de-watering of the well, and yet provide an adequate water supply for the intended use of the well.

Well drillers do not use a standardized procedure when performing pump tests. This causes a wide variation in results, and may cause inaccurate or faulty measurements. The duration of pumping can be of paramount importance to results achieved. Short duration tests can lead to an overestimation of the extended capacity of a well. A six inch wide well can hold approximately 1.5 gallons for every foot below the water table. If the pump test is not conducted long enough to pump out the standing water column, little can be said about the overall capacity of the aquifer involved.

The measurement by some drillers of the drawdown realized during the pump test appears to be unreliable. The driller's misuse of pump test readings can be due to any of the following reasons:

- he has failed to subtract the beginning static water level from the depth-to-water at the end of the test;

- he has equated pumping rate with drawdown;

- he has tested the post-test water level after too long a time period, thereby allowing water levels to recover, which leads to an underestimate of the drawdown;

- he has not adequately monitored the pumping rate to ensure pumpage at the expected rate, thereby resulting in a higher yield determination than is actually the case.

Another factor which leads to a misinterpretation of pump test data is that the driller is most interested in developing a well which will meet his client's needs. Therefore, the pump test is usually run at a pumping rate that is at or slightly higher than the rate that water must be supplied to meet these needs. This means that the determined "developed capacity" represents a lower limit of the potential capacity of the aquifer. When evaluating surrounding wells for the potential capacity at a projected well site, this limitation must be borne in mind. Yields higher than those previously developed may, in fact, be available.

The final limitation regarding driller performed pump tests may be the most serious from a management standpoint. These do not typically provide information as to adverse effects on nearby wells from the established pumping rate. A pump test performed by a groundwater hydrologist, on the other hand, typically involves monitoring water effects in a nearby well or wells, and often involves monitoring the recovery rate in both the test well and surrounding wells as well. It is only when such information is developed, that pumping rates which will protect surrounding wells can be determined.

Static Water Levels

The static water level measurement is intended to provide an indication of the elevation of the water table when not influenced by pumping. As will be discussed in the following section, this information is useful for determining groundwater level fluctuations and movement directions. One can never be sure that the reported static level is not influenced by pumping at nearby wells. Thus, the reported static level should be assumed to be the lower limit of the true value. Further limitations in use of this measurement relate to natural groundwater level fluctuation which is discussed in Section 3.2.

Well Log Data Management Applications

In summary, no other source of groundwater information is as potentially useful as the data provided by "Well Logs and Drillings Reports". However, until such time that descriptions and procedures used become standardized by those completing these reports, they must be interpreted with caution. Confidence in interpretation is increased when a large number of well logs are available for use. At the same time, a non-conforming well log should not be dismissed out of hand, because it may, in fact, represent local variations in the subsurface geology or hydrology.

To help insure optimal use of well log information, all logs which are available to the township should be acquired, interpreted at least in a preliminary way, and incorporated into the groundwater data base. It must be emphasized that, whereas generalized interpretations of groundwater conditions may be valid on a township scale, individual site analyses require access to the information contained in specific well logs. Map plots of various kinds of site specific information contained in the logs can be very useful in the identification or evaluation of groundwater conditions at a select site. These conditions include:

- The aquifer or aquifers likely to be encountered when drilling, and the depth below ground surface where they will be found;

- The likely depth to which a well must be drilled to provide for an adequate water supply. This will help insure that a well is drilled deep enough to provide a steady water supply, and is not drilled to an unnecessary depth, which would increase development costs with little added return. This target depth, coupled with knowledge of materials to be drilled through, can assist landowners in estimating well development costs.

- A determination of the likely yield to be developed. This helps to minimize risks of developing a supply insufficient to meet requirements.

3.2 Groundwater Levels Data

The term "groundwater level" refers to the elevation at a given location below which all pore spaces in the geologic materials present are saturated with water. This point is known as the water table surface elevation or more simply as the water table. In map view the water table conforms to a subdued version of the surface contours with elevation typically being highest under hills and lowest in stream valleys. In the climate of northeast Ohio where precipitation exceeds 46 per year on an average, the water table will be coincident with both the surface of streams which are free flowing year round and the surface of most lakes and ponds. Beneath the highest hills in the township, the water table may lie as much as 50-100 feet below the surface.

Defining the groundwater level is important for two reasons. First, the depth to water measurement is a primary factor in determining how deep wells must be drilled to secure and maintain a steady water supply. Second, the contour of the water table determines groundwater flow directions and has a large influence on how pollutants introduced into the ground will migrate.

Whereas the general form of the water table contour is generally controlled by the surface relief, water table height or depth is also affected by seasonal, climatic, and man-induced factors. Moreover, water table contours are not static but are constantly changing in response to external stresses. Seasonal fluctuations in water table elevation are comparatively small, on the order of 10 feet or less over the course of a year. The water table is generally highest in the late winter and spring when groundwater is heavily recharged by snow melt and the spring rains. It is lowest during dry summer periods when precipitation, and concomitantly, recharge rates are lowest, and vegetation water demands and evaporation rates are highest.

Climatic fluctuations are much more pronounced than annual (or seasonal) fluctuations. They range from as much as 40-50 feet at the Chagrin Falls well field in northwest Bainbridge Township. Extended periods of low infiltration associated with dry years cause an overall lowering of groundwater levels. On the other hand, wet periods are associated with high water levels.

Man-induced fluctuations are predominantly caused by pumping at well sites. As water is pumped out of a well the surrounding area is dewatered and the local groundwater level decreases. This decrease is additive. This means that pumping from one well diminishes the water available to nearby wells producing from the same aquifer. The amount of decrease realized is a function of the pumping rate, the relative rate of water movement in the surrounding earth materials, and the magnitude of effects at the other nearby pumping wells. The absolute magnitude of fluctuations induced by pumping is limited only by the depth of a water well. At some locations in the township this might result in a potential drop in the water surface in excess of 200 feet. It should be noted that water levels do tend to be restored after pumping has ceased. The net drop in local levels is a balance between the amount of water pumped out and the rate that supplies are naturally replenished.

Direction of Groundwater Flow

Groundwater moves in response to pressure differentials which exist in the ground. Direction of movement is from high areas (high pressure) to low areas (low pressure). Thus in Bainbridge Township the general trend of groundwater movement is from the east to the west. Local flow directions, however, can be in virtually any direction depending on the location of low areas in the groundwater surface contours. A groundwater contour map is the means by which local flow directions can be determined. Such a map has been prepared for Bainbridge Township using information developed by the USGS, in association with the adjusted static water levels reported on available well logs. (See Plate 8). This map is valid for inferring medium to large scale effects. However, heavy pumping at one or more wells can alter local levels to the extent that the local groundwater flow direction (small scale effects) is altered to reflect migration to the well(s).

Adjustments to Reported Level Data

The static levels reported on well logs can be useful in establishing groundwater contours, and for identifying areas where water supply development has resulted in a lowering of the water table. The primary limitation in the use of this data stems from the fact that the wells have been developed over a 25-year period and during all seasons of the year. Thus, the one-time measurement at a given well will be influenced by seasonal, climatic, and possibly, man-induced fluctuations. A table (see Appendix B) has been prepared whereby a water level determination during a given month and year can be adjusted to represent the long-terms average condition, by factoring out the seasonal and climatic factors. This table was constructed with the use of the long-term water level records available for the Village of Chagrin Falls well field located in the northwest corner of the township. It should be recognized that these factors are approximate because water levels may vary at lower or greater rates in portions of the township that are removed from the recording well.

Groundwater Management

The foregoing is a discussion of groundwater levels, fluctuations in those levels, and movement of water in response to the levels. This discussion must be now considered in terms of groundwater management. As previously noted, groundwater levels are dynamic and are constantly changing. Therefore, a groundwater contour map depicts conditions at one particular point in time. It is, therefore, not a tool to be used with impunity. A basic understanding of the limitations inherent in interpreting groundwater effects will make this tool more useful. First of all, areas of high water elevations are generally more susceptible to change than are areas of low elevations. Second, areas near a groundwater divide are likewise more susceptible to change than areas removed from it. Third, the analysis of long-term effects of a given change is less susceptible to error than are short-term effects.

A groundwater manager should have confidence that the overall view at the township level of the groundwater contour map is not likely to change significantly over time. Therefore, only periodic monitoring of water levels at select locations will be necessary to keep this map current. Management focus should be directed to existing or potential "hot" spots where over-development of an aquifer may result in an adverse lowering of the water table or where pollutant contamination is a potential or actual concern.

A development proposal can be evaluated for potential impacts on surrounding lands with use of the groundwater contour map. This is true whether the proposal deals with a housing complex, oil and gas well fields, chemical waste storage facilities, or any similar development.

An evaluation should include an analysis of those areas which lie both hydraulically downslope from the proposal area and upslope of local groundwater discharge areas represented by perennial streams. It is these areas which are most susceptible to deleterious impacts from a development. Potential for impacts will be highest when the area is already highly developed and lowest when little groundwater use is currently realized.

3.3 Groundwater Quality Data and Analyses

There are at least four important uses of groundwater quality data for community level groundwater management: 1) insuring the existence of safe, potable water supplies; 2) documenting background levels so as to definitely identify man-induced changes; 3) tracing pollutants back to their source, and 4) providing long-term maintenance of a potable supply.

These four data uses generally represent a decreasing scale of sampling intensity. The determination of the safeness of existing water quality typically involves analysis of a large number of samples for a wide variety of parameters. The basis of the sample design is that little is known about the quality of individual wells, and there is some uncertainty as to the presence of unknown pollution sources. The documentation of background water quality levels is necessary in the vicinity of existing or proposed potential pollution sources. The list of chemical parameters that need to be analyzed can be limited to those associated with possible sources.

Sampling designed to trace contamination back to the source would need to be undertaken only when a pollution problem is discovered. In this case, parameters would be restricted to those in violation of drinking water standards and, possibly, include those capable of "fingerprinting" the specific source. Maintenance monitoring would generally be undertaken after all other sampling had been accomplished and after all potential source areas had been identified. The sampling network can be limited to stations below concentrations of potential sources, and include rotating stations elsewhere. Parameters can also be limited to those found to be problematic during earlier surveys.

4.0 PROGRAMMATIC RECOMMENDATIONS

Elements 2.0 and 3.0 above provide a community level groundwater resources management baseline for Bainbridge Township. In order for a groundwater management program to be effective, a series of ongoing activities should be begun and continued on an ongoing basis. These activities are summarized in the present section in the form of recommendations.

The recommendations can be largely carried out by township personnel. Each activity consists of three basic phases: 1) data collection, 2) data reduction and presentation, and 3) data interpretation. Resource limitations preclude the completion of all recommended activities at all possible sites. The recommendations recognize this limitation and are, therefore, structured to provide information only as needed to make a groundwater decision. It must be emphasized that the township cannot proceed with an effective management program without limited professional geotechnical assistance. The programs outlined below minimize occasions when such assistance would be required. All procedures suggested employ standardized information with predefined inherent strengths and limitations. The recommendations maximize use of available relevant information in a given analysis. With the implementation of this program, groundwater decisions would be based upon best available data. Recommendations are summarized in Table 4 below.

1. RELOCATE ALL WELLS ON THE TWO-FOOT CONTOUR MAPS AVAILABLE FROM THE GEAUGA COUNTY ENGINEERS OFFICE. EXACT WELL LOCATIONS SHOULD BE DETERMINED BY FIELD SURVEYS OR WITH LANDOWNER ASSISTANCE.

   OBJECTIVE: to maximize the information base available by establishing the proper orientation of wells and their relative surface elevations. This enhances water level analyses, aquifer identification, and multiple well interrelationships.

METHODOLOGY: the location of wells requires simple map reading skills and familiarity with topographic map elevation determination. Well elevations determined to within two feet of actual elevations are generally adequate.

PERSONNEL REQUIRED: this activity requires limited professional assistance at the outset but after that can be accomplished by township employees and resident participation. Well locations can be established by township personnel when visiting a property for some other purpose. Also residents can provide information when they visit the townhall for normal social, business or civil purposes. Map booths could be set up at school events or other community affairs. Local well drillers may be willing to assist in locating wells or in identifying proper well log assignments.

TIMING: new wells should be located immediately as should any wells to be included in a monitoring network (see Recommendations 2 and 4). Priority should be given to locating wells where an existing or suspected groundwater problem exists, and to areas surrounding proposed or potential development sites. As the information base becomes enlarged, focus should shift to areas with a lower density of information and to areas near aquifer divides. Short-term emphasis can be placed in areas of conflicting data or highly variable conditions.

NECESSARY RESOURCES: This activity includes the costs of two-foot contour maps.

SPECIAL CONSIDERATIONS: located wells should be paired with the appropriate well logs. Thus, the township should secure previously unsecured well logs from ODNR. As located well logs become available, they should be added to the inventory of information contained in Appendix A.

2. INITIATE A WATER WELL LEVEL MONITORING PROGRAM.

OBJECTIVE: water well level data are used to establish local flow directions and to monitor water table fluctuations, including those caused by over-development of an aquifer. Reliable information about well levels can assist in identifying safe yields, and help to promote water conservation during times of diminished recharge.

METHODOLOGY: the measurement of the static level in a well is a relatively straightforward procedure. The first step is to establish a common reference or measurement point, such as the top of the well casing, and to relate this point to a ground surface elevation. It then remains to determine the distance from this point to the groundwater surface. Various techniques are available for measuring the depth to water in a well casing including the use of float gauges, conductivity meters, and chalked lines or measuring tapes.

Multiple water level measurements are most useful when they are taken at a single point in time or closely approximate this. Attempts to minimize any effects from pumping in the test well or in nearby wells further add to the reliability of the data. Since water usage is generally minimal overnight in private residences, early morning measurement of water levels may be best. Weekly or monthly measurements are generally adequate for most purposes.

PERSONNEL REQUIRED: most level measurements can be made by co-operative township residents. Community participation allows for a large number of simultaneous measurements. At the same time it increases public awareness of groundwater resource issues and helps to promote support for an ongoing groundwater management program. Township personnel would be needed to provide supervision and training assistance, and to record and compile measurements that are made. Township personnel could also provide quality assurance oversight and may be needed to perform periodic monitoring in response to a specialized evaluation need.

The opening of well caps for this type of monitoring must be coordinated with the Geauga County Health Department to prevent well contamination.

NECESSARY RESOURCES: reliance on community volunteers for water level measurements can greatly reduce costs associated with this activity. Measurement tools such as measurement tapes and float gauges are generally available and would, therefore, bear little cost to the program. The township would need to devote the time of some personnel to training and supervision. Data recording may be performed inhouse as well. Time required may be expected to average several person hours a week over the long-term. Data analysis costs would vary depending on the sophistication of the monitoring program. Early in the program, professional assistance is necessary to refine data analysis techniques and procedures. After the program is under way, professional assistance would be limited to responding to specific problems or issues which might arise. Should such assistance be needed, the existence of a good water level data base will greatly facilitate problem evaluation, thereby reducing its cost.

SPECIAL CONSIDERATIONS: a concerted effort to collect and analyze water level data offers the township a wide ranging set of benefits. While local variations always exist, conditions encountered in developed areas of the township can be used to guide the assessment of impacts on undeveloped sections having similar aquifer characteristics. A well defined groundwater flow map can be instrumental in defining zones of impact from over-development of the aquifer system or from pollution episodes. Should a major groundwater pollution event occur, detailed knowledge of groundwater flow directions is immensely important to successfully containing and removing the polluted water.

Wells to be included in the monitoring network should of necessity be accessible and not have obstructions that prevent the determination of the water level. As a general rule, the more wells that are included in the network, the better the data that will be generated. In highly developed areas, only representative wells need to be monitored. In areas of high groundwater relief, fewer wells may be required than in areas of low relief. As distance from aquifer divides increases, monitoring well density can decrease.

An annual review of the groundwater contour map may be desirable. It is recommended that this review be based upon the month with the lowest groundwater levels.

3. INVENTORY POTENTIAL POLLUTION SOURCES IN THE TOWNSHIP

OBJECTIVE: to identify potential pollution producing sites and to establish priority pollutants in various locales. Knowing what kind of potential pollutants exist and where sources are located is crucial in establishing targeted monitoring and management programs. It also helps insure that water quality tests analyze groundwater samples for pertinent chemicals, while avoiding the unnecessary expense of testing for exotic chemicals that are unlikely to be found in the water. Such an inventory can save time and expense in isolating and correcting a problem when pollutants are found in the water supply at any well.

METHODOLOGY: possible pollution sources include industrial sites, chemical or waste storage sites, waste treatment facilities, gas stations and other storage tanks, injection wells, gas and oil wells and brine storage pits, pesticide application or storage sites, salt piles and roadway de-icing application sites, areas of home heating fuel oil use, and other similar sources.

All source sites need to be map-located preferably on the same scale as the groundwater flow direction map. While the location of most potential pollutant sources are probably known to individuals in the township zoning and fire departments, accurate locations in times of emergency or when evaluating water quality conditions is mandatory.

Overlap or interaction of several potential pollutant sources can also be beneficial in maximizing the utility of quality monitoring programs by identifying priority areas of concern.

Questionnaires sent to local industries could identify the type and volume of chemicals used or stored on site. If not already known, gas station operators should be contacted to determine the type and quantity of fuel oils stored on site. They should also be able to supply information on the type and frequency of storage tank integrity testing performed at their stations. The parent oil companies could be contacted to determine fingerprint chemicals in their products so that spill response testing can differentiate materials as to likely source.

<u>PERSONNEL REQUIRED</u>: township personnel could be the primary source of information regarding potential pollution sites. Developing information on potentially hazardous materials locations and on gas and oil well locations is integral to this task. The Department of Agriculture can provide information on pesticide use areas.

<u>NECESSARY RESOURCES</u>: costs could be limited for the most part to township personnel time necessary to collect, organize and plot this information on maps.

4. INSTITUTE A GROUNDWATER QUALITY MONITORING AND ASSESSMENT PROGRAM

OBJECTIVE: the primary objective of quality monitoring is to identify the potability of the water supply. A secondary objective is to provide documented background levels of various chemicals to be used to defend the identification of any future pollution episodes.

METHODOLOGY: the first step in this program is to secure all groundwater quality information currently available. Primary sources of this information include the Geauga County Health Department, the Ohio Environmental Protection Agency, the United States Geological Survey, public and semi-public water supply operators, water conditioning companies operating in the township, local industries (who may have conducted special analyses to determine suitability of the water supply for production purposes), and private well owners. All of the above parties should be requested to supply copies of any future testing data.

The second step is to establish a water quality screening network whereby samples are collected and sent to certified drinking water supply testing laboratory. These laboratories test for characteristic chemical species which provide an indication of possible contamination or pollution. Priorities for township initiated sampling should focus on the following: (1) areas of suspected problems; (2) concentrations of potential pollution sources; (3) concentrations of water use; (4) sampling of each of the four major aquifer systems (for background documentation); and (5) areas of high recharge or infiltration rates.

The third step is to establish a program to collect, preserve, and store water samples in areas potentially subject to heavy metal contamination. This includes, specifically, industrial sites, chemical disposal and storage sites, gas and oil wells, brine pits and disposal areas, fuel oil storage locations, and deep well sites. These samples can be held for up to one year prior to analysis. Should a suspected problem arise, these samples can document earlier conditions, particularly if taken up-gradient and down-gradient from the suspected source.

PERSONNEL REQUIRED: the level of expertise involved in water quality monitoring varies with the intended use of the data and the sensitivity of the analysis. Screening and background documentation testing requires minimal training. Samples required to document a pollution episode which are likely to be used in a court action should, however, be collected by professionals in accordance with an approved quality assurance plan.

NECESSARY RESOURCES: water quality screening tests are available from a number of laboratories for approximately $50/sample. Bacterial contamination scans are available locally for $6-15/sample. Heavy metal analyses can run as much as $200/sample.

5. ORGANIZE A COMPUTER DATA BASE OF GROUNDWATER INFORMATION

OBJECTIVE: to make all applicable groundwater data readily available when needed. This insures that all available data are included in a groundwater evaluation, and reduces the time and expense of conducting such evaluations.

METHODOLOGY: it is necessary to key computer based information to map locations. Superimposing a grid cell system over a township map may be the best way to accomplish this. A 200 x 250 foot grid is suggested.* Well locations could be numbered by cell coordinates allowing for easy map location and computer file access. Potential pollution sources and water quality data can be keyed to this grid as well.

PERSONNEL REQUIRED: the township will require professional assistance to define and construct the data base and the software necessary to operate it. A data base manager would need to be appointed and trained to use the system.

NECESSARY RESOURCES: the initial creation of the data base may require two to three weeks of data entry time, assuming that information from 2,000 wells was available for inclusion. Future requirements would be limited to entering new well data or other data, and the preparation of summary reports as needed.

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* This cell size corresponds to the typical size of a computer printer character if a base map at the 1:24000 scale is used. This is the scale of the USGS quadrangle maps. Use of this scale can allow the generation of computer assisted maps.

TABLE 4
SUMMARY OF RECOMMENDATIONS

	Task	Scale and Frequency	Resources
1(A)	Train township personnel in well location and well log interpretation procedures.	One training session	Professional Assistance
(B)	Refine well locations and plot on topographic maps.	Potential of 2,000 existing wells	Township Personnel
(C)	Correct, update and expand well log data base.	Ongoing	Data Manager
2(A)	Train township personnel and residents in static level measurement procedures.	One training session	Professional Assistance
(B)	Conduct measurements.	Monthly with an initial target of 50 wells	Residents with township assistance
(C)	Validate and compile data.	Estimated one-person day/month	Data Manager
(D)	Review groundwater contour map.	Annually at one to two weeks/year	Data Manager
3(A)	Inventory and locate potential groundwater contamination sources on topographic maps.	Estimated two weeks to establish	Township Personnel
(B)	Survey local industries regarding type and volumes of chemicals in use.	Estimated one week	Township Personnel
(C)	Identify targeted water quality monitoring locations and parameters of concern.	Estimated two days	Professional Assistance

TABLE 4
SUMMARY OF RECOMMENDATIONS
(Cont.)

	Task	Scale and Frequency	Resources
4(A)	Compile available groundwater quality data.	Estimated two weeks	Data Manager with Professional Assistance
(B)	Establish water quality screening network (based upon 3(C) results above.	To be developed	To be developed
(C)	Implement monitoring program.		
(D)	Train township personnel in procedures to maintain monitoring program.		
5(A)	Establish computerized groundwater data base.	Estimated one week	Professional Assistance
(B)	Train township personnel in use and maintenance of system.	One training session	Professional Assistance
(C)	Operate and maintain data base system.	On-going	Data Manager

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APPENDIX A

SUMMARY OF WELL LOG DATA

well number	log no.	well elevation	static level	static height	depth of well	aquifer type	surface formation	test rate	test duration	draw-down	gal/foot	contacts
1	261505	1205	28	1177	93	p	p	20	1	40	30	
2	301009	1205	30	1175	82	p	p	16	1	70	14	
3	411759	1205	36	1169	92	p	p	20	1.5	90	20	
4	638972	1115	33	1082	121	p	p	15	1	88	10	
5	327904	1170	38	1132	320	b	p	25	24	182	198	pc:1101 cb:902 bd:856
6	167967	NA	20	NA	112	p	p	3	2	92	4	?
7	235943	NA	25	NA	60	p	p	10	2	5	240	?
8	235945	NA	50	NA	100	c	c			NA	NA	
9	232704	1200	40	1160	80	p	p	10	1	15	40	
10	355807	1165	28	1137	65	p	p	12	1	9	80	?
11	235940	NA	25	NA	73	p	p	16	1	33	29	
12	298046	NA	50	NA	100	p	p	25	0.5	25	30	
13	320992	NA	40	NA	115	c	c	12	4	40	72	
14	167981	NA	24	NA	72	p	p	8	2	63	15	
15	267874	1215	30	1185	74	p	p	6	1	74	5	
16	265673	1140	65	1075	160	p	p	28	6	71	142	pc:1018
17	616057	NA	160	NA	265	c	p	6	2	20	36	
18	488080	1105	35	1070	82	p	p			NA	NA	
19	488081	1110	40	1070	87	p	p			NA	NA	
20	327905	1185	19	1166	85	p	p	19	24	61	449	pc:1106
21	250141	1215	40	1175	70	p	p			NA	NA	
22	505267	1195	34	1161	105	p	p	52	6	46	407	
23	459294	1065	NA	NA	85	u	u			NA	NA	
24	459292	1065	-5	1070	52	u	u	15	2	15	120	
25	205530	1165	15	1150	36	p	p	15	1	0.01	90000	
26	320960	NA	26	NA	100	p	p			NA	NA	
27	181401	NA	10	NA	49	p	p	15	3	30	90	
28	207533	1205	25	1180	70	p	p	8	1	30	16	
29	387372	1155	21	1134	106	p	p	15	1	57	16	pc:1101
30	279619	1140	33	1107	76	u	u	15	1	50	18	
31	209589	1145	30	1115	97	p	p	15	4	20	180	
32	209573	1145	30	1115	100	p	p	15	4	0.01	360000	
33	209563	1150	30	1120	80	p	p	12	4	10	288	
34	209571	1150	20	1130	85	p	p	15	4	15	240	
35	287531	1165	40	1125	80	p	p	5	2	10	60	
36	209567	1160	36	1124	80	p	p	14	4	14	240	pc:1082
37	209601	1150	35	1115	85	p	p	14	4	0.01	336000	
38	209588	1145	15	1130	87	p	p	20	4	0.01	480000	
39	320511	1130	20	1110	88	u	u	28	1	30	56	
40	345354	1135	20	1115	80	p	p	16	2	10	192	
41	621090	995	63	932	162	b	b	10	0.5	99	3	bd:858
42	529531	995	61	934	150	b	c	30	2	6	600	cb:877
43	523186	995	49	946	126	b	b	12	24	21	823	bd:870
44	597365	985	20	965	116	u	u	15	2	20	90	
45	214458	1225	80	1145	140	p	p	20	2	20	120	
46	209583	1215	50	1165	115	p	p	7.5	4	10	180	
47	209585	1205	50	1155	115	p	p	7.5	4	50	36	
48	194684	1190	45	1145	90	p	p	6	1	0.01	36000	
49	241150	1190	48	1142	95	p	p	15	1	15	60	
50	209586	1205	65	1140	110	p	p	15	4	0.01	360000	
51	209572	1205	55	1150	105	p	p	10	4	35	69	
52	263542	1185	45	1140	96	p	p	15	4	20	180	
53	508390	1225	72	1153	128	p	p	15	1	12	75	
54	613422	1215	40	1175	121	p	p	25	2	81	37	pc:1095
55	479899	1190	42	1148	96	p	p			NA	NA	

NA:NOT AVAILABLE P:POTTSVILLE Fm B:BEREA Fm U:UNCONSOLIDATED DEPOSITS D:DEVONIAN ROCKS